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Biological Services Program

FWS/OBS-77/54
SEPTEMBER 1977

# COMPARISON OF SELECTED OPERATIONAL CAPABILITIES OF FIFTY-FOUR GEOGRAPHIC INFORMATION SYSTEMS

Interagency Energy-Environment Research and Development Program
Office of Research and Development • U. S. Environmental Protection Agency

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and Wildlife Service

Department of the Interior

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues which have an impact fish and wildlife resources and their supporting ecosystems. The mission of the Program is as follows:

1. To strengthen the Fish and Wildlife Service in its role as a primary source of information on natural fish and wildlife resources, particularly with respect to environmental impact assessment.

2. To gather, analyze, and present information that will aid decisionmakers in the identification and resolution of problems associated with major land and water use changes.

3. To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decisionmaking process, to prevent or minimize the impact of development on fish and wildlife. Biological Services research activities and technical assistance services are based on an analysis of the issues, the decisionmakers involved and their information needs, and an evaluation of the state-of-the-art to identify information gaps and determine priorities. This is a strategy to assure that the products produced and disseminated will be timely and useful.

Biological Services projects have been initiated in the following areas:

Coal extraction and conversion

Power plants

Geothermal, mineral, and oil shale development

Water resource analysis, including stream alterations and western water allocation

Coastal ecosystems and Outer Continental Shelf development.

Systems and inventory, including National Wetlands Inventory, habitat classification and analysis, and information transfer

The Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams which provide the Program's central, scientific and technical expertise, and which arrange for contracting of Biological Services studies with States, universities, consulting firms, and others; Regional staff who provide a link to problems at the operating level; and staff at certain Fish and Wildlife Service research facilities who conduct inhouse research studies.

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September 1977

# COMPARISON OF SELECTED OPERATIONAL CAPABILITIES OF FIFTY-FOUR GEOGRAPHIC INFORMATION SYSTEMS

By

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U.S. DEPARTMENT OF THE INTERIOR

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# 1.0 INTRODUCTION

## 1.1 Goal of Project

This project is defined and sponsored by the Western Energy and Land Use Team (WELUT) to promote more effective consideration of fish and wildlife resources in the numerous state and federal decisions concerning western land, energy, mineral and water resources.

The goal of this two year project is to develop an operational capability within the U.S. Fish and Wildlife Service (FWS) to accept, store, manipulate and output spatially related data for use in a variety of FWS programs. This includes not only the data that has been and will continue to be collected by the FWS, but also includes data available in computerized and non-computerized data files of other federal and state natural resource management agencies. This goal is to be achieved with minimal development of new computer software and minimal hardware requirements. The project will start on a prototype basis within selected test case areas and will broaden to other applications.

The primary users of this system in its developmental stages are in the Billings Area Office (BAO) of the U.S. Fish and Wildlife Service. The biologists in this office are faced with the weekly task of assessing the wildlife resource impacts of various land use changes. This project will attempt to develop simple, usable, practical tools for operational use at the regional and area office level, as well as more sophisticated tools for research users.

## 1.2 Description of Major Tasks of the Project

It is helpful to outline the seven major tasks of this project. This report falls within Task II.

| | |
|---|---|
| Task I | Assess the spatial data needs of three groups of users: 1) The Denver Region Six offices of FWS, 2) the Billings Area Office within Region Six, and 3) Special Projects of the Office of Biological Services. Development of a preliminary system design based on these needs. |
| Task II | Survey, assess, and compare existing computer software systems and geographic data bases which are relevant to FWS determined needs. This may include federal, state, and private software and data bases. |
| Task III | Develop an interim software system and test data base(s) covering the pilot test area(s). (WELUT Montana-Wyoming test area). |
| Task IV | Benchmark test and evaluate the most promising geographic information system software as determined from Task II. |
| Task V | Implement the selected software system on a government computer as determined by FWS-WELUT. |

Task VI Test and debug the new FWS-WELUT geographic information system and document it with both users and technical manuals.

Task VII Train FWS personnel in the applications, use and limitations of the system. This task will be on-going throughout the project.

## 1.3 Purpose

This report presents the results of the initial evaluation of the "off the shelf" computer software for possible inclusion in the FWS GIS. This evaluation is based on three previous efforts:

1) User Needs Assessment (Report 1.1)
2) General GIS System Description (Report 1.2)
3) Detailed GIS System Description (Report 2.1)

To summarize, based on the user needs assessment, the GIS is visualized as containing four major sub-systems. Each sub-system in turn is comprised of other modules (Figure 1). The FWS GIS must operate under certain operational constraints and must perform certain logical functions (Report 2.1). This initial evaluation of existing GIS software is based primarily on operational criteria, such as programming language and documentation. However, functional criteria are also considered. For example, suppose a piece of software were not operational on a favored computer, but the function it performs is vital to meet FWS requirements. This software package then receives a higher rating.

## 2.0 THE CRITERIA USED IN EVALUATION

As mentioned above, two sets of criteria were considered. "Operational" criteria refer to the general hardware/software characteristics of a particular program. "Functional" criteria refer to the actual logical function(s) or tasks performed by a piece of software. The initial evaluation and selection process is based primarily on the operational criteria. A second evaluation will be made based on the functional capability criteria alone. This two-phased selection process is being followed to allow the large number of GIS programs to be systematically evaluated.

Figure 2 presents the operational criteria for the FWS GIS. The definition of operational criteria was constrained by the fact that FWS (Region 6) must use either a Data General Eclipse or a CDC CYBER for a mainframe. FORTRAN was selected as the favored language because it is universally applied an generally understood in the GIS user community. The remainder of the operational criteria are based on FWS user specifications, good programming practices, or software transportability considerations.

The functional criteria which define required capabilities of the system (ability to input, composite, display data, etc.) are listed in Appendix A. These criteria have not yet been applied to these 54 systems, but will be used in a later step.

## 3.0 THE SYSTEMS EVALUATED

Concurrent with the user needs assessment and preliminary system design, documentation was gathered on existing GIS. For the purpose of this project, a system is defined as any piece of GIS software that performs more than one unique GIS function, such as data input, data analysis, and data display. The reason for this division is to separate single purpose software from multi-purpose GIS software in order to keep the number of systems to be evaluated as small as possible.

References to different systems came from many sources, including IGU (1975), McDonald (1975), Power (1975), and from personnel experience of the staff. For each system, documentation on actual system applications, users manuals, and technical manuals were obtained where available. The documentation search ended July 15, 1977, after four months, and nearly 85 different systems had been defined. These 85 geographic information systems are listed in Table 1. Of these 85, we obtained sufficient documentation to write 2 to 5 page standardized descriptions on 52 systems. Figure 3 presents a condensed version of the standardized description. The standardized descriptions were used as the information base for evaluation.

## 4.0 EVALUATION PROCEDURE

Only the 52 systems with sufficient documentation were further considered in the process, since undocumented software generally are not portable.

A set of the standardized system descriptions were prepared and distributed to several technical and managerial staff. Each individual was given a week to read and relate each system to first, the operational, and second, the functional criteria. Based on this evaluation each individual decided whether a system should be: 1) considered further for adoption, 2) considered only for functions or algorithms, or 3) dropped from further consideration.

At the end of the week, the group convened to compare the results of individual evaluations. Each system was discussed and voted on. Table 2 is a summary table of the results of the evaluation. The information presented in Table 2 represents summary characteristics from available documentation. In some cases, local modifications to the systems will result in characteristics different from those shown in this summary table. The summary should then be viewed as an overview of some of the geographic information systems. More detailed systems descriptions are available from the contact person in column 2 of the table.

Originally, the evaluation was intended to be purely objective, quantitatively based on the operational criteria. However, in reality, this initial selection process was both an objective and subjective decision process, due to trade-offs in the operational and functional characteristics of each system. A quantitative number could not be derived that would adequately reflect all the components of the evaluation process. Thus the final decision was one of professional judgement, conditioned by the criteria contained in Figure 2.

## 5.0 SUMMARY AND FINDINGS

Based on the initial evaluation, eleven complete systems and pieces of fourteen systems have been selected for further study. The eleven complete systems are:

COMPIS - Comarc Corporation
CRIS - BLM
CMS-II - Department of Commerce
EPPL 4 - Minnesota Land Management Information System
GIMMS - University of Edinburgh, Scotland
LUMAD - USGS Geography Program
ORRMIS - Oak Ridge National Lab
PLUSX - PLUS2 - University of Western Ontario
WRIS - U.S. Forest Service
CONGRID - U.S. Forest Service
The SAG SYSTEM - Fish and Wildlife Service

The fourteen partial systems are indicated in Table 2. The partial systems vary from complete modules to algorithms.

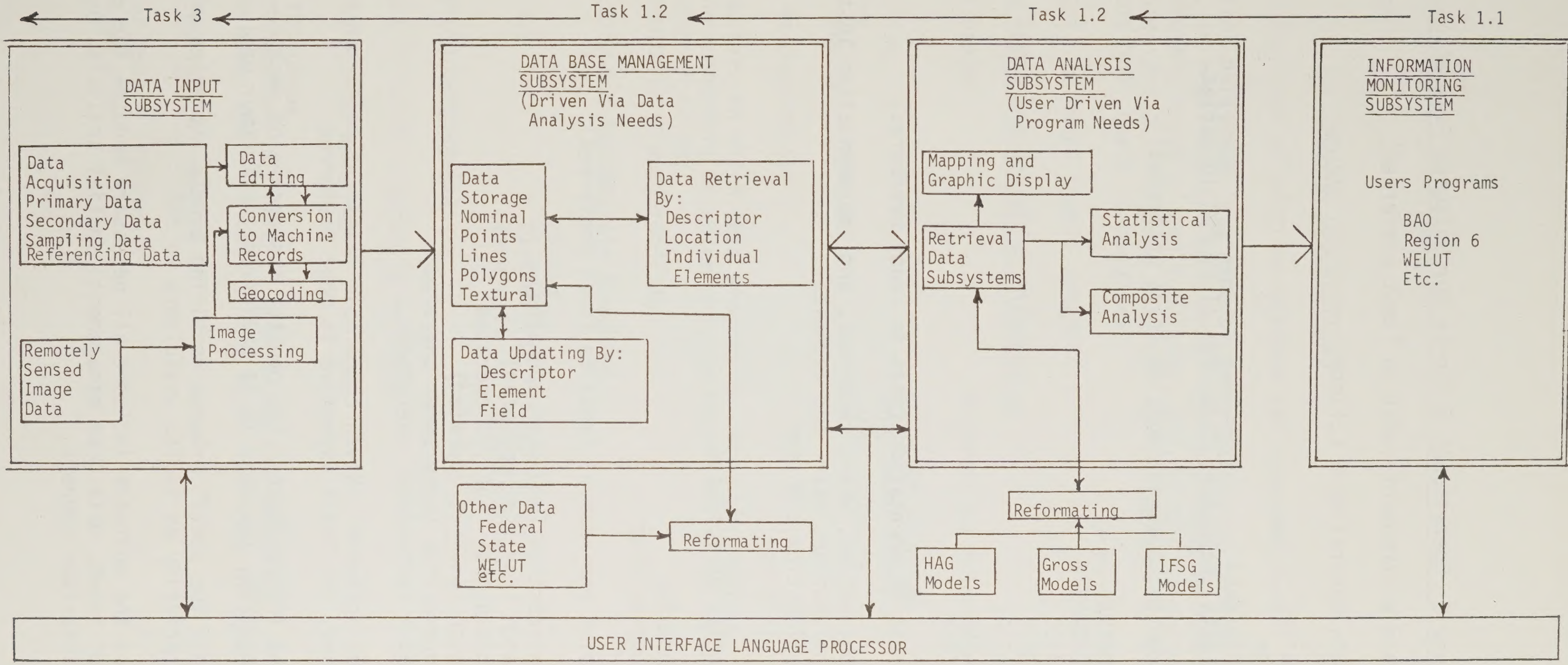
## 6.0 NEXT EVALUATION STEPS

Both the eleven complete systems and the nineteen "selected functions" will be analyzed in more detail.

Actual systems architecture and program code will be studied to determine the transportability, programming techniques, and efficiencies for each system. The pieces of software that rank highest in these evaluations will then form basic building blocks for the FWS GIS.

Figure 1

PRELIMINARY GEOGRAPHIC INFORMATION SYSTEM DESIGN


Task 3
Task 1.2
Task 1.2
Task 1.1
DATA INPUT SUBSYSTEM
Data Acquisition Primary Data Secondary Data Sampling Data Referencing Data
Data Editing
Conversion to Machine Records
Geocoding
Remotely Sensed Image Data
Image Processing
DATA BASE MANAGEMENT SUBSYSTEM (Driven Via Data Analysis Needs)
Data Storage Nominal Points Lines Polygons Textural
Data Retrieval By: Descriptor Location Individual Elements
Data Updating By: Descriptor Element Field
Other Data Federal State WELUT etc.
Reformating
DATA ANALYSIS SUBSYSTEM (User Driven Via Program Needs)
Mapping and Graphic Display
Retrieval Data Subsystems
Statistical Analysis
Composite Analysis
Reformating
HAG Models
Gross Models
IFSG Models
INFORMATION MONITORING SUBSYSTEM
Users Programs
BAO
Region 6
WELUT
Etc.
USER INTERFACE LANGUAGE PROCESSOR

## Figure 2 Operational Criteria for Software Evaluation

A. Hardware environment (most to least preferred)

1. Data General/Nova Eclipse
2. CDC
3. UNIVAC
4. IBM
5. Interdata
6. Digital Equipment Corp. PDP II or PDP 10 series

B. Programming Language (most to least preferred)

1. FORTRAN IV
2. FORTRAN V
3. BASIC
4. COBOL
5. PASCAL
6. ALGOL
7. other

C. Available Documentation (most to least preferred)

1. application, user, technical, and implementation instructions
2. application, user, and technical
3. application and user
4. application

D. Modularity of software

yes modular
no non-modular

E. Operation environment (most to least preferred)

1. interactive (end user operated)
2. batch (end user operated)
3. interactive (analyst operated)
4. batch (analyst operated)
5. interactive (programmer operated)
6. batch (programmer operated)

F. Cost of software - Given comparable levels of performance between programs, the least expensive is most preferred.

G. Machine independence - the greater the degree of machine independence of a program, the more it is preferred for further evaluation.

H. Any "off the shelf" program requiring exotic libraries will receive a low priority as to its usefulness to FWS.

I. Whether the software included all necessary modules for a "complete system" input, data base management, spatial analysis, output, and user interface support.

## Figure 3

SYSTEM ASSESSMENT

## PROGRAM DESCRIPTIONS

1. Identification (name of program--acronym and extended name)

2. Purpose (first paragraph is a general description; succeeding paragraphs, if required, are more specific; they cover method used, unusual features, range of applicability, and related programs). Use space provided on this page and continue on the back of this page if additional space is required.

3. Sample Output Is there sample output?

4. Programming Basis and Operating Information

   a. Mode of usage:

      batch
      interactive
      real time
      other (specify)

      Program-use interface:

      end user operated
      programmer operated
      other (specify)

   b. Operative Computer(s)

      1. computers on which this program is currently running:
      2. other computers on which program should run with little or no modification:
      3. Comments on transferability:

   c. Fast Memory and Peripherals Required:

      core
      word size
      tape(s)
      disk(s)
      plotters(s) (specify type)
      terminals (specify type)

   d. Programming Language(s):

      languages in which program is written:

   e. Operating System Required:

   f. Data Files Used:
      (Indicate whether any special data files are required. If so, indicate name, description, storage mode, and type of geocoding).

5. Program Evaluation Information

   a. Number of source statements
   b. Compilation time

- c. Any special libraries required
- d. Execution time (specify criteria basis, such as number of variables, options, number of data points, etc.)

6. Origin of Program

    - a. Author name
    - b. Organization
    - c. Is program supported?
      If yes, specify support organization and type of support provided.
    - d. Documentation

7. Availability

    - a. Contact for acquisition (name and address)
    - b. Acquisition conditions (indicate costs where applicable)

        lease
        exchange
        free of charge
        subscription fee
        handling mailing only
        royalty payment
        specific users only
        distribution for everyone

    - c. Materials available in installation package:

        program manuals
        source code
        object code
        sample input
        sample output

    - d. Status of release: _____tested _____evaluated

8. Description Prepared

    Name
    Organization
    Title
    Date

## TABLE 2
## LIST OF 85 EXISTING GEOGRAPHIC INFORMATION SYSTEM

| System Acronym | Agency, University, or Business Organization | System Acronym | Agency, University, or Business Organization |
|---|---|---|---|
| ADAPT | W.E. Gates & Associates | GRID | E.S.R.I. |
| AUTOMAP | E.S.R.I. | GRID | Harvard |
| BNDRYNT | Univ. of British Columbia | IBIS | Cal Tech, Jet Propulsion Lab |
| CADDS | Computer Division, Inc. | IMAGE | Univ. of Saskatchewan |
| CAM | C.I.A. | IMGRID | Harvard University |
| CART 8 | Instronics | INFORM | U.S. Forest Service |
| CGIS | Canada Land Inventory | JURIS | University of Michigan |
| CLARI | Colo. State University | LCO-ELF | (from secondary reference) |
| CMS I | U.S. Dept. of Commerce | LEMS | State of Louisiana |
| CMS II | FRMS | LIMAP | State of South Dakota |
| COMLUP | U.S. Forest Service | LUAS | NASA |
| COMPIS | Comarc Design Systems | LUIS | Univ. of Massachusetts |
| CONGRID | U.S. Forest Service | LUMAD | U.S. Geological Survey |
| CONPLOT | Defense Mapping Agency Topo Labs | LUMIS | Cal Tech |
| CRIS | Bureau of Land Management | LUMP | Univ. of California |
| ECOMAP | Colo. State University | MAG I | State of Maryland |
| EPPL | Earth Systems Research, Inc. | MAP/MODEL | Univ of Oregon |
| EPPL-2 | Earth Systems Research, Inc. | METLAND | Univ. of Massachusetts |
| EPPL-4 | State of Minnesota | MIADS-2 | U.S. Forest Service |
| GADS | I.B.M. | MIDAS | State of Maine |
| GELO | Soil Conservation Service | MLMIS | State of Minnesota |
| GIM | U.S. Forest Service | MOSAIC | U.S. Forest Service |
| GIMMS | Univ. of Edinburgh, Eng. | MSDAMP | University of Iowa |
| GMAPS | Colo. School of Mines | NARIS | University of Illinois |
| GRASP | Univ. of Wisconsin | NORMAP | Univ. of Lund, Sweden |

## TABLE 2 (Cont.)

| System Acronym | Agency, University, or Business Organization |
|---|---|
| NRIS | Raytheon, Corp. |
| OASIS | National Oceanic and Atmospheric Adminstration |
| ORRMIS | Regional Environmental Systems Analysis Program, Oak Ridge |
| PIOS II | E.S.R.I. |
| PLANMAP | State of Washington |
| PLOT | U.S. Forest Service |
| PLUS/2 | University of Western Ontario |
| PLUS X | University of Western Ontario |
| POWER | Virginia Polytechnic Institute |
| PTOLEMY | Batelle Labs |
| RAMP | U.S. Forest Service |
| RAP | NASA |
| READ | State of North Dakota |
| SACARTS | Defense Mapping Agency Topo Labs |
| SAG | U.S. Fish and Wildlife Service |
| SNAPS | Defense Mapping Agency Topo Labs |
| SPIT | Soil Conservation Service |
| STOPIN | Engineering Topo Labs, U.S. Army |
| STORET | Environmental Protection Agency |
| TIGRIS | National Parks Service |
| TMSFRG | Swedish government |
| TOPAS | U.S. Forest Service |
| TRAS | University of Massachusetts |
| TVA | Tennessee Valley Authority |
| UDIS | (from secondary reference) |
| WRAP | Tennessee Valley Authority |
| WRIS | U.S. Forest Service |

## TABLE 2

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation* | Program Operation Environment | Exotic Libraries? | Acquisition mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| ADAPT | W.E. Gates & Assoc.<br>1515 Cincinnati - Batavia Pike<br>Batavia, Ohio 45103<br>(513)732-1212 | IBM 370 or PDP 15 | FORTRAN | 2 | Batch & Interactive | No | unknown | IRREGULAR Triangular GRID | IBM= up to 200K bytes | selected functions |
| AUTOMAP II | E.S.R.I.<br>380 New York St.<br>Redlands, CA 92373<br>(714)793-2853 | IBM 360 | FORTRAN | 3 | Batch | No | one time lease | Cell | 240 K bytes | No |
| BNDRYNT | IBM version - David Douglas<br>Ministry of Urban Affairs<br>Ottawa, Canada<br>D.G. version - Carl Reed<br>1 Drake Pk., #142<br>333 W. Drake Road<br>Ft. Collins, CO 80521 | IBM 360<br>Data General Nova 840 | FORTRAN | 3 | Batch & Interactive | No | handling/ mailing | line and polygon | IBM= approx 120K bytes<br>DG= 32 K bytes | selected functions |
| CADDS/3 | COMPUTERVISION<br>201 Burlington Rd.<br>Bedford, MA 01730<br>1-617-275-1800 | Data General, Nova 1200, Eclipse | 98% FORTRAN<br>2% Assembler | 2 | Interactive | No | purchase agreement | Arc, polygon, point | 128 K bytes | selected algorithms |
|  | 1. technical, users, installation instructions, & application<br>2. application, users, technical<br>3. appl., user<br>4. application |  |  |  |  |  |  |  |  |  |

*see criteria sheet for description of level of documentation.

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Acquisition mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| CAM | IBM version:<br>U.S. Dept. of Comm.<br>N.T.I.S.<br>5285 Port Royal Rd.<br>Springfield, VA 22151<br>CDC version:<br>Dept. of Geog.<br>SUNY Buffalo<br>4224 Ridge Lea Rd.<br>Amherst, NY 14226 | IBM 360<br>CDC 6400 | FORTRAN | 2 | Batch | No | handling/ mailing | point, line, polygon | IBM= 250 K bytes<br>CDC= 150 K words | selected functions |
| CART-8/ INTERMAP | Instronics, Ltd.<br>171 Neil Avenue<br>Stittsville, Ont.<br>Canada KOA 3G0 | PDP 8e<br>PDP 11 | Assembler, some FORTRAN | 1 | Interactive | No | General lease | symbol, point, line, polygon, alpha | 32 K bytes | selected algorithms |
| CGIS | Dick Switzer<br>Land Management Info. Systems<br>Lands Directorate<br>Environ. Canada<br>Ottawa, Ontario | IBM 360<br>IBM 370 | PL-1/X (maj.), Assembler | 2 | Batch and Interactive | unknown | unknown | line | 300-1000 K bytes | selected algorithms |
| CMS-I | U.S. Dept. of Commerce<br>Economic Development Admin.<br>Washington, D.C. | UNIVAC 1108<br>CDC 6400 | FORTRAN | 1 | Batch | No | handling/ mailing | cell | 250 K bytes | No |
| CMS-II | Federation of Rocky Mtn. States<br>Suite 300-B<br>2480 W. 26th Ave.<br>Denver, CO 80211 | IBM 360/370<br>CDC-CYBER | COBOL + FORTRAN IV | 1 | Batch | No | handling/ mailing | input=polygon or cell;<br>analysis=cell | 260 K bytes | Yes |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| COMPIS | COMARC Design Systems<br>575 Union Blvd., Suite 102<br>Lakewood, CO 80228<br>303-988-5830 | Data General Eclipse C-330 or S-230 | FORTRAN | 1 | Interactive | No | purchase (w/ options) or lease | input=line, point, polygon<br>analysis=line, point, polygon, cell | 64 K bytes | Yes |
| COMLUP | U.S. Forest Service<br>Fort Collins Computer Center<br>3825 E. Mulberry<br>Ft. Collins, CO<br>303-493-5800 | CDC 3100<br>UNIVAC 1110 | FORTRAN | 3 | Batch - some Interactive | No | handling/ mailing | input=arc;<br>storage=polygon;<br>analysis=cell | CDC= 32K words | selected functions |
| CONGRID | Richard Hokans<br>Univ. of Georgia<br>School of Forest Resources<br>Athens, Georgia | IBM 360/370<br>UNIVAC 1108 | FORTRAN | 2 | Interactive | No | handling/ mailing | cell | IBM= 250 K bytes | Yes |
| CRIS | Bob Green<br>BLM<br>Den. Fed. Center<br>Denver, CO | CDC CYBER | FORTRAN | 3 | Batch and Interactive | No | handling/ mailing | input=polygon<br>analysis= polygon, cell | unknown | Yes |
| ECOMAP | Dr. Charles Bonham<br>College of Forestry & Nat.Resources<br>Colo. State Univ.<br>Ft. Collins, CO 80521 | CDC 6400<br>CDC CYBER 172 | FORTRAN | 3 | Batch | No | handling/ mailing | cell | 100 K words | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| EPPL2 | Earth Systems<br>Research, Inc.<br>3402 Univ. Ave.,SW<br>Minneapolis, Minn.<br>55414<br>612-339-5109 | CDC 6400 | FORTRAN | 3 | Batch | No | unknown | cell | 60-150 K words | No |
| EPPL4 | MLMIS | CDC 6400 | FORTRAN | 3 | Batch | No | unknown | cell | 60-150 K words | Yes |
| EZ-MAP | Dr. Charles Bonham<br>College of Forestry<br>& Nat. Resources<br>C.S.U.<br>Ft. Collins, CO<br>80521 | CDC 6400 | FORTRAN | 3 | Interactive | No | handling/ mailing | cell | 65 K words | No |
| GIMMS | PLU Document<br>Librarian<br>U. of Edinburg<br>Rm 3217, JCMB<br>Kings Bldg.<br>Mayfield Rd.<br>Edinburg, Scotland | IBM 360<br>ICL 4175 | FORTRAN | 2 | Batch and Interactive | No | handling/ mailing | Points, lines, polygons | IBM=<br>190 K bytes | Yes |
| GMAPS | K. Turner<br>Colo. School of<br>Mines<br>Golden, Colorado | DEC-10 | FORTRAN | 4 | Interactive | No | unknown | cell | unknown | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| GRASP | Dr. William Gates<br>Inst. for Environ. Studies<br>U. of Wisconsin | UNIVAC 1108 | FORTRAN and Assembler | 3 | Interactive | IODR-file manager at Wisconsin | handling/ mailing | cell | unknown | selected functions |
| GRID | Lab. for Computer Graphics & Spatial Analysis<br>Grad. School of Design<br>Harvard Univ.<br>520 Gund Hall<br>48 Quincy Street<br>Cambridge, MA 02138<br>(617)495-2526 | IBM 360<br>Burroughs 6700 | FORTRAN | 3 | Batch | No | Purchase | cell | IBM=<br>150 K bytes | No |
| IBIS | Nevin Bryant<br>Jet Propulsion Lab<br>Cal Tech<br>Pasadena, CA 91103 | VICAR Image System | FORTRAN | 3 | Interactive | VICAR display software | unknown | polygon-Landsat (cell) | unknown | No |
| IMAGE | Dr. A.R. Boyle<br>Dept. of Elec. Engineering<br>U. of Saskatchewan<br>Saskatoon, Saskatchewan, Canada | DEC PDP 8-e | Assembler | 2 | Interactive | No | purchase | point, line, polygon, alpha | 32 K bytes | selected algorithms |
| IMGRID | Lab. for Computer Graphics & Spatial Analysis, Grad. Sch. of Design, Harvard<br>520 Gund Hall<br>48 Quincy St.<br>Cambridge, Mass.<br>(617)495-2526 | IBM 360 | FORTRAN | 3 | Batch | No | small purchase fee | cell | 32 K bytes | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition Mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| IRIS/ NARIS | Peter Allsberg<br>Center for Adv. Computation<br>U. of Illinois<br>Urbana-Champaign<br>Urbana, IL 61801 | Burroughs 6700 | ALGOL | 3 | Interactive | No | Handling/ mailing | Irregular grid | unknown | selected algorithms |
| LEMS | Rockwell International<br>Space Division | UNIVAC 1108 | FORTRAN,<br>COBOL,<br>Assembler | 2 | Batch | No | unknown | points,<br>lines,<br>polygons,<br>text | unknown | No |
| LUAS | NASA<br>Nat. Space Tech. Labs<br>Bay St. Louis, Miss. 39520 | UNIVAC 1108<br>CDC-CYBER | FORTRAN IV | 2 | Batch | No | handling/ mailing | input=cell,<br>polygon;<br>analysis=cell | UNIVAC= 240 K bytes<br>CDC= unknown | selected functions |
| LUMP | Dr. R. Johnson<br>Div. of Envir. Studies<br>U. of Calif.<br>Davis, CA | Burroughs 6700 | ALGOL | 3 | Batch and Interactive | No | subscription fee | cell | unknown | No |
| LUMAD | Dr. J. Anderson<br>Geog. Program<br>USGS, Nat. Center<br>Reston, VA | IBM 370<br>D.G. Nova 840 | FORTRAN | 2 | Batch and Interactive | No | handling/ mailing | input=line;<br>analysis=cell,<br>polygon | Nova= 64 K bytes<br>IBM= 320 K bytes | Yes |
| LUMIS | C. Paul<br>Jet Propulsion Lab<br>Cal Tech<br>Pasadena, CA 81103 | IBM 360 | FORTRAN + ALGOL | 3 | Interactive | No | unknown | line & cell | unknown | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition Mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| LIMAP | S. Dakota State<br>Planning Bureau<br>State Capitol Bldg.<br>Pierre, SD 57501 | IBM 360/370 | FORTRAN | 3 | Batch | No | unknown | Landsat | unknown | No |
| MAGI | E.S.R.I.<br>380 N. York St.<br>Redlands, CA 92373<br>(714)793-2853 | IBM 360 | FORTRAN | 2 | Batch | No | project basis | cell | unknown | No |
| MAP/ MODEL | Bur. of Governmental Research & Service<br>U. of Oregon<br>Portland, OR | IBM 360/370 | FORTRAN & PL/1 | 3 | Batch | No | handling/ mailing | polygon | 113 K bytes | selected algorithms |
| MIADS/2 | Computer Services Librarian<br>Pacific SW Forest & Range Experiment Station<br>P.O. Box 245<br>Berkeley, CA 94701 | IBM 7040,<br>IBM 7090,<br>UNIVAC 1110 | FORTRAN,<br>MAP | 3 | Batch | No | handling/ mailing | alpha, cell | IBM= 64 K bytes | No |
| MIDAS | State of Maine | RCA Spectra 70 | FORTRAN,<br>Assembler | 3 | Batch | Yes | unknown | alpha, line, point, polygon | 130 K bytes | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition Mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| MLMIS (see also EPPL) | Allen Robinette<br>Minn. State Planning Ofc.,<br>Capitol Square Bldg.<br>550 Cedar St.<br>St. Paul, MN 55101 | CDC 6400 | FORTRAN | 2 | Batch | No | unknown | irregular cell<br>¼,¼ section<br>PLS | unknown | No |
| MOSAIC | SEAM, USDA<br>Forest Service<br>145 Grand Ave.<br>Billings, MT 59102 | CDC 7600, IBM 370, UNIVAC 1110 | FORTRAN | 2 | Batch | No | Handling/ mailing | Digital terrain (point) | IBM= 240 K bytes | Selected features |
| MSDAMP | Dr. K. Dueker<br>Inst. of Urban & Regional Research<br>U. of Iowa<br>Iowa City, IA 52242 | IBM 360 | FORTRAN | 3 | Batch | No | handling/ mailing | cell | unknown | selected features |
| NORMAP | S. Nordbeck<br>Dept. of Geog.<br>U. of Lund<br>Lund, Sweden | UNIVAC | FORTRAN & ALGOL | 3 | Batch | No | unknown | line | unknown | selected functions |
| NRIS | Raytheon Corp.<br>Autometric Corp. | IBM 360-370 | FORTRAN | 2 | Batch | No | handling/ mailing | input=line;<br>analysis= line, polygon. | unknown | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition Mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| ODYSSEY (not yet a system) | Lab. for Computer Graphics & Spatial Analysis<br>Grad. School of Design<br>Harvard Univ.<br>520 Gund Hall<br>48 Quincy St.<br>Cambridge, MA 02138<br>(617)495-2526 | PDP-10, CDC, IBM | FORTRAN IV | N/A | Interactive | No | unknown | polygon, line | unknown | n/a |
| ORRMIS | Richard Durfee<br>ORNL<br>Regional Urban Studies Dept.<br>P.O. Box X<br>Oak Ridge, TN 37830<br>(615)483-8611 | IBM 360-370 | FORTRAN - 1 assembler | 2 | Batch | No | handling/ mailing | hierarchial cell | 210 K bytes | Yes |
| PIOS-II | Comprehensive Planning Organization<br>San Diego, CA | Burroughs 6700 | FORTRAN | 2 | Batch and Interactive | No | Small purchase fee | polygon + cell | 76 K bytes | selected functions |
| PLUS | Dr. M. Goodchild<br>Dept. of Geog.<br>U. of W. Ontario<br>Ontario, Canada | IBM 360, PDP11<br>CDC CYBER 173 | FORTRAN | 2 | Batch and interactive | No | unknown | storage=polygon;<br>analysis=cell | depends on computer | Yes |
| POWER | D. Clair Jones<br>Dept. of Fisheries & Wildlife Sci.<br>VA Polytechnic Institute<br>Virginia | IBM 370 | FORTRAN, PL/I | 2 | Batch | No | handling/ mailing | cell | up to 330 K bytes | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition Mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| PTOLEMY | E.R Hill<br>Battelle<br>Pacific NW<br>Laboratories<br>Richland, VA 99352 | PDP 11/45 | FORTRAN IV | 3 | Interactive | Yes -Vetor General | unknown | polygon | 64 K bytes | selected functions |
| RAP | Gary Rockwood<br>Bureau of Economic & Bus. Research<br>College of Bus.<br>U. of Utah | UNIVAC 1108 | FORTRAN | 3 | UNIVAC Denmark mode | No | handling/ mailing | storage= point,arc, polygon.<br>analysis=cell | unknown | No |
| REAP* | Dr. A. William Johnson<br>REAP Director<br>316 N. Fifth St.<br>Room 521<br>Bismark, ND 58505 | ← UNKNOWN → | | | | | | | | unsure |
| SAG | Jack Gross<br>Ecol. Modelling Team, FWS<br>One Drake Park<br>Suite 260<br>333 W. Drake Rd.<br>Ft. Collins, CO | CDC 6400 | FORTRAN | 2 | Interactive | No | unknown | polygon | 50 K words | Yes |
| STOPIN | A. Gunther<br>U.S. Army Engineer<br>Topog. Lab<br>Ft. Belvoir, VA | CDC 6600 | FORTRAN | 2 | Batch and interactive | No | handling/ mailing | alpha | 75 K words | No |

| System | Contact | Hardware Environment (CPU) | Programming Language | Level of Documentation | Program Operation Environment | Exotic Libraries? | Normal Acquisition Mode | Geographic Data Type | Required Memory | FRMS Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| SYMAP | Lab. for Computer Graphics & Spatial Analysis, Graduate School of Design, Harvard Univ.<br>520 Gund Hall<br>48 Quincy St.<br>Cambridge, MA 02138<br>(617)495-2526 | IBM 360-370<br>CDC machines | FORTRAN | 3 | Batch | No | purchase | cell | IBM=<br>75 K bytes | No |
| TITOPO | Peggy Morgan<br>Data Systems Div.<br>NPS<br>US Dept. of Int.<br>Washington, D.C. | IBM 370 | FORTRAN | 2 | Batch and interactive | No | non-proprietary portions handling/mailing | digital terrain | unknown | selected functions |
| TOPAS | Ft. Collins Computer Center<br>Forest Service<br>3825 E. Mulberry<br>Ft. Collins, CO<br>493-5800 | UNIVAC 1110 | FORTRAN | 2 | Batch and interactive | No | unknown | Digital terrain | unknown | selected functions |
| WRIS | Computer Services Librarian<br>Pacific SW Forest and Range Exper. Station<br>P.O. Box 245<br>Berkeley, CA 94201 | UNIVAC 1110 | FORTRAN, Assembler | 2 | Batch | No | handling/mailing | polygon | unknown | Yes |

* Need more information

# BIBLIOGRAPHY

IGU Commission on Geographical Data Sensing Processing. 1975. Software for Spatial Data Handling.

McDonald, Mary V. 1975. A Wildlife and Natural Resources Information System for Virginia. unpublished Master's thesis proposal. Dept. of Fisheries and Wildlife, Virginia Poly Tech Institute and State University, Blacksburg, Virginia.

Power, Margaret. 1975. Computerized Geographic Information Systems: An Assessment of Important Factors in Their Design Operation and Success. Center for Technology Development, Washington University. Report No. CDTDM-RCT - 75/3.

# APPENDIX A
# FUNCTIONAL CRITERIA FOR SOFTWARE EVALUATION

## A) DATA INPUT

### Required Data Types
- point (water wells)
- arc (National Wetlands Inventory data)
- polygon loop (a common mode for encoding and storing polygons - WRIS, PLOT, PIOS)
- raster (Landsat, scanner input)
- grid (a common, inexpensive method of encoding geographic data - related to raster)
- textual (information describing the above data: its accuracy, source, and other characteristics, plus bibliographies, documents.)

### Format of Required Data
- ability to adjust for different scales
- the ability to transform from digitizer coordinates to a common coordinate system.
- the ability to transform from one projection to another. So far, the most commonly cited projections are Latitude-Longitude, State Plane, UTM, Lambert Conformal, and Public Land Survey (Township-Range).

### Edit during Encoding
- point data editing abilities
- arc data editing abilities
- polygon data editing
- raster data editing
- textual data editing

### Post Edit
- delete duplicate or unnecessary points, arcs, polygons, rasters or points in arcs and polygons (weeding).
- locate logical errors
- projection change to geographic reference system of data base
- conversion from table coordinates to data base coordinates

### Operating Environment for Data Input (summary)
- ability to encode map data
- ability to encode text data
- ability to handle classified Landsat images
- ability to input a coarse level (1 encoded point per inch of line) or at a fine level (20 points per inch of line).
- ability to interactively interface with the encoding process, especially for edit purposes
- ability to display both textual and graphic data

## B) DATA BASE MANAGEMENT

### General Characteristics of FWS GIS Data Base Management System
- ability to support many users
- ability to support many data sets
- ability to store both small and large data sets

### Data Update
- ability to add new data
- ability to delete existing data

**BIBLIOGRAPHIC DATA SHEET**

1. Report No. FWS/OBS-77/54

2.

3. Recipient's Accession No.

4. Title and Subtitle
Comparison of Selected Operational Capabilities of
Fifty-four Geographic Information Systems

5. Report Date
September 1977

6.

7. Author(s)
Larry Salmen, James Gropper, John Hamill and Carl Reed

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Information Systems Technical Laboratory
Federation of Rocky Mountain States, Inc.
One Drake Park, Suite 142, 333 W. Drake Road
Fort Collins, Colorado 80521

10. Project/Task/Work Unit No.
WELUT No. 002-76

11. Contract/Grant No.
14-16-0008-2155

12. Sponsoring Organization Name and Address
Western Energy and Land Use Team, Office of Biological
Services, U.S. Fish and Wildlife Service
Drake Creekside Building, 2625 Redwing Road
Fort Collins, Colorado 80521

13. Type of Report & Period Covered

14.

15. Supplementary Notes

Coal Funds; EPA-IAG-D5-E685; L.C. Number 77-90894.

16. Abstracts

The report compares selected operational capabilities of 54 existing computer software systems and geographic data bases. This task was performed as part of a two-year project to develop a similar system for the U.S. Fish & Wildlife Service, to accept, store, manipulate and output spatially-related data.

In comparing the various geographic information systems, two sets of criteria were considered: "operational" criteria referring tot he general hardware and software characteristics of a particular program, and "functional"criteria referring to the actual logical function or tasks performed by specific software.

17. Key Words and Document Analysis. 17a. Descriptors

geographic information system
spatially-related data
geographic data bases
computer software systems
FORTRAN

17b. Identifiers/Open-Ended Terms

U.S. Fish & Wildlife Service

17c. COSATI Field/Group

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## U. S. Department of the Interior

## Fish and Wildlife Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

March 3, 1849